CLAIMS

What is claimed is:

1. A flexible hose adapted for conveying fluids under pressure, said hose extending in an axial direction along a central longitudinal axis to an indefinite length, and in a radial direction circumferentially about said longitudinal axis, said hose comprising:

a core tube having a circumferential inner core tube surface and an opposing circumferential outer core tube surface;

a first reinforcement layer surrounding the outer core tube surface, said first reinforcement layer being formed of one or more filaments of at least a first fiber; and

at least a second fiber reinforcement layer surrounding said first reinforcement layer, said second reinforcement layer being formed of one or more filaments of at least a second fiber,

wherein said second reinforcement layer is bonded to said first reinforcement layer by a bonding agent, only a portion of the filaments of said first reinforcement layer and of said second reinforcement layer being wetted by said bonding agent.

2. The hose of claim 1 wherein the bond between said first and said second reinforcement layer is at least about 6 pli (1.07 kg/linear cm).

3. The hose of claim 1 wherein said portion of the filaments of said first reinforcement layer and of said second reinforcement layer being wetted by said bonding agent comprises between about 0.5-20% by total weight, number, or volume average of said filaments.

4. The hose of claim 1 wherein said bonding agent comprises an adhesive, resin, plasticizer, tackifier, or solvent

5. The hose of claim 1 wherein said bonding agent comprises a thermoplastic resin.

6. The hose of claim 5 wherein said thermoplastic resin is selected from the group consisting of polyamides, polyesters, polyolefins, fluoropolymers, silicones, polyvinyl chlorides, thermoplastic elastomers, and thermoplastic hot-melts.

7. The hose of claim 5 wherein said bonding agent further comprises an adhesion promoter compounded with said thermoplastic resin.

8. The hose of claim 1 wherein said bonding agent comprises a first resin layer disposed adjacent said first reinforcement layer and a second resin layer different from said first resin layer disposed adjacent said second reinforcement layer.

9. The hose of claim 5 wherein said thermoplastic resin is filled with an electrically-conductive filler to render said resin electrically-conductive.

10. The hose of claim 5 wherein said thermoplastic resin and said filaments forming said first and said second reinforcement layer each are generally hydrophobic, said hose thereby being rendered electrically non-conductive.

11. The hose of claim 1 wherein said bonding agent is a plasticizer, tackifier, or solvent which comprises an organic acid, a phenol, or an amine.

12. The hose of claim 1 wherein:

said first reinforcement layer is spiral wound in a first winding direction around the outer core tube surface; and

said second reinforcement layer is spiral wound in a second winding direction opposite said first winding direction around said first reinforcement layer.

13. The hose of claim 12 wherein:

said first reinforcement layer is spiral wound from one or more ends of a first yarn comprised of filaments of at least said first fiber; and

said second reinforcement layer is spiral wound from one or more ends of a second yarn comprised of filaments of at least said second fiber.

14. The hose of claim 13 wherein:

said first yarn as spiral wound over said core tube has an outer course of filaments of said first fiber which defines a circumferential first outer reinforcement surface disposed adjacent said second reinforcement layer, substantially only said outer course of filaments of said first reinforcement layer being wetted by said bonding agent; and

said second yarn as spiral wound over said first reinforcement layer has an inner course of filaments of said second fiber which defines a circumferential second inner reinforcement surface disposed adjacent said first reinforcement layer, substantially only said inner course of filaments of said second reinforcement layer being wetted by said bonding agent.

15. The hose of claim 1 wherein said filaments forming said first reinforcement layer and said filaments forming said second reinforcement layer each are treated with an adhesion promoter.

16. The hose of claim 1 wherein said core tube is formed of one or more layers of a polymeric material selected, independently, from the group consisting of polyamides, polyesters, polyacetals, ethylene vinyl alcohol, polyoxymethylene, polyolefins, silicones, fluoropolymers, polyvinyl chloride, polyurethanes, natural and synthetic rubbers, and copolymers and blends thereof.

17. The hose of claim 1 wherein said core tube comprises an innermost core tube layer of a first thermoplastic material which defines said inner core tube surface, and an

outermost core tube layer of a second thermoplastic material which defines said outer core tube surface.

18. The hose of claim 17 wherein first thermoplastic material is chemically-resistant, and wherein said second polymeric material has a flexural modulus which is lower than the flexural modulus of said first polymeric material.

19. The hose of claim 18 wherein said first thermoplastic material comprises a fluoropolymer, and wherein said second thermoplastic material is selected, independently, from the group consisting of polyamides, polyolefins, polyvinyl chlorides, polyurethanes, polyesters, polyacetals, ethylene vinyl alcohol, polyoxymethylene, silicones, thermoplastic rubbers, fluoropolymers, polyolefins, and copolymers and blends thereof.

20. The hose of claim 1 wherein said first fiber and said second fiber are selected, independently, from the group consisting of nylon fibers, polyester fibers, aramid fibers, polyvinyl alcohol fibers, polyvinyl acetate fibers, polyolefin fibers, polyphenylene bezobisoxazole fibers, metal wires, and blends thereof.

21. The hose of claim 20 wherein said first fiber and said second fiber are the same.

22. The hose of claim 1 further comprising a cover surrounding said second fiber reinforcement layer.

23. The hose of claim 22 wherein said cover is formed of one or more layers of a polymeric material selected, independently, from the group consisting of polyurethanes, polyamides, polyolefins, silicones, polyesters, fluoropolymers, thermoplastic elastomers, polyvinyl chlorides, polyurethanes, natural and synthetic rubbers, and copolymers and blends thereof.

24. The hose of claim 22 wherein said cover comprises an innermost cover layer of a first thermoplastic material which defines a circumferential interior cover surface, and an outermost cover layer of a second thermoplastic material which defines a circumferential exterior cover surface.

25. The hose of claim 24 wherein said first thermoplastic material has a flexural modulus which is lower than the flexural modulus of said second thermoplastic material, and wherein said outermost layer is formed of a second polymeric material which has a hardness of at least about 60 Shore A durometer.

26. The hose of claim 25 wherein said first thermoplastic material is selected from the group consisting of polyamides, polyolefins, polyvinyl chlorides, silicones, fluoropolymers, polyurethanes, natural and synthetic rubbers, and copolymers and blends thereof, and wherein said second thermoplastic material is selected, independently, from the group consisting of polyamides, polyurethanes, polyesters, polyolefins, fluoropolymers, and copolymers and blends thereof.

27. The hose of claim 22 wherein said cover has a circumferential interior cover surface and an opposing circumferential exterior cover surface, said interior cover surface being bonded to said second reinforcement layer.

28. The hose of claim 1 wherein:

said first reinforcement layer is formed from one or more ends of a first yarn comprised of filaments of said first fiber, said first yarn having an outer course of filaments of said first fiber which defines a circumferential first outer reinforcement surface disposed adjacent said second reinforcement layer, substantially only said outer course of filaments of said first reinforcement layer being wetted by said bonding agent; and

said second reinforcement layer is formed from one or more ends of a second yarn comprised of filaments of said second fiber; said second yarn having an inner course of filaments of said second fiber which defines a circumferential second inner reinforcement

surface disposed adjacent said first reinforcement layer, substantially only said inner course of filaments of said second reinforcement layer being wetted by said bonding agent.

29. The hose of claim 1 wherein:

said first reinforcement layer is formed from one or more ends of a first yarn comprised of a blend or cord of filaments of said first fiber and a third fiber different from said first fiber; and

said second reinforcement layer is formed from one or more ends of a second yarn comprised of a blend or cord of filaments of said second fiber and a fourth fiber different from said second fiber,

said first and said second fiber being selected to be wetted by said bonding agent, and said third and fourth fibers being selected to be substantially not wetted by said bonding agent.

30. The hose of claim 1 wherein:

said first reinforcement layer is formed from one or more ends of a first yarn comprised of filaments of said first fiber, and one or more ends of a third yarn different from said first yarn comprised of filaments of a third fiber different from said first fiber; and

said second reinforcement layer is formed from one or more ends of a second yarn comprised of filaments of said second fiber, and one or more ends of a fourth yarn different from said second yarn comprised of filaments of a fourth fiber different from said second fiber,

said first and said second fiber being selected to be wetted by said bonding agent, and said third and fourth fibers being selected to be substantially not wetted by said bonding agent.

31. The hose of claim 29 wherein:

said first fiber and said second fiber are the same; and

said third and said fourth fiber are the same.

32. The hose of claim 30 wherein:

said first fiber and said second fiber are the same; and

said third and said fourth fiber are the same.

33. A method of making a flexible hose adapted for conveying fluids under pressure, said hose extending in an axial direction along a central longitudinal axis to an indefinite length, and in a radial direction circumferentially about said longitudinal axis, said method comprising the steps of:

(a) providing a core tube having a circumferential inner core tube surface and an opposing circumferential outer core tube surface;

(b) providing a first reinforcement layer around the outer core tube surface, said first reinforcement layer being formed of one or more filaments of at least a first fiber;

(c) providing at least a second fiber reinforcement layer around said first reinforcement layer, said second reinforcement layer being formed of one or more filaments of at least a second fiber; and

(d) bonding said second reinforcement layer to said first reinforcement layer by a bonding agent which is applied in a flowable phase which wets only a portion of the filaments of said first reinforcement layer and of said second reinforcement layer.

34. The method of claim 33 wherein the bond between said first and said second reinforcement layer is at least about 6 pli (1.07 kg/linear cm).

35. The method of claim 33 wherein said portion of the filaments of said first reinforcement layer and of said second reinforcement layer being wetted by said bonding agent in step (d) comprises between about 0.5-20% by total weight, number, or volume average of said filaments.

36. The method of claim 33 wherein said bonding agent applied in step (d) is an adhesive, resin, plasticizer, tackifier, or solvent.

37. The method of claim 33 wherein the viscosity of the flowable phase of the bonding agent applied in step (d) is at least about 20,000 centipoise.

38. The method of claim 33 wherein said bonding agent applied in step (d) comprises a thermoplastic resin.

39. The method of claim 38 wherein said thermoplastic resin is selected from the group consisting of polyamides, polyesters, polyolefins, fluoropolymers, silicones, polyvinyl chlorides, thermoplastic elastomers, and thermoplastic hot-melts.

40. The method of claim 38 wherein said bonding agent further comprises an adhesion promoter compounded with said thermoplastic resin.

41. The method of claim 33 wherein said bonding agent applied in step (d) comprises a first resin layer disposed adjacent said first reinforcement layer and a second resin layer different from said first resin layer disposed adjacent said second reinforcement layer.

42. The method of claim 38 wherein said thermoplastic resin is filled with an electrically-conductive filler to render said resin electrically-conductive.

43. The method of claim 38 wherein said thermoplastic resin and said filaments forming said first and said second reinforcement layer each are selected to be generally hydrophobic, said hose thereby being made electrically non-conductive.

44. The method of claim 33 wherein said bonding agent applied in step (d) is a plasticizer, tackifier, or solvent which comprises an organic acid, a phenol, or an amine.

45. The method of claim 33 wherein:

said first reinforcement layer is provided in step (b) as spiral wound in a first winding direction around the outer core tube surface; and

said second reinforcement layer is provided in step (c) as spiral wound in a second winding direction opposite said first winding direction around said first reinforcement layer.

46. The method of claim 45 wherein:

said first reinforcement layer is spiral wound in step (b) from one or more ends of a first yarn comprised of filaments of at least said first fiber; and

said second reinforcement layer is spiral wound in step (c) from one or more ends of a second yarn comprised of filaments of at least said second fiber.

47. The method of claim 46 wherein:

said first yarn as spiral wound in step (b) over said core tube has an outer course of filaments of said first fiber which defines a circumferential first outer reinforcement surface disposed adjacent said second reinforcement layer, substantially only said outer course of filaments of said first reinforcement layer being wetted by said bonding agent in step (d); and

said second yarn as spiral wound in step (c) over said first reinforcement layer has an inner course of filaments of said second fiber which defines a circumferential second inner reinforcement surface disposed adjacent said first reinforcement layer, substantially only said inner course of filaments of said second reinforcement layer being wetted by said bonding agent in step (d).

48. The method of claim 33 wherein said core tube provided in step (a) is formed of one or more layers of a polymeric material selected, independently, from the group consisting of polyamides, polyesters, polyacetals, ethylene vinyl alcohol, polyoxymethylene, polyolefins, silicones, fluoropolymers, polyvinyl chloride, polyurethanes, natural and synthetic rubbers, and copolymers and blends thereof.

49. The method of claim 33 wherein said filaments forming said first reinforcement layer and said filaments forming said second reinforcement layer each are treated with an adhesion promoter.

50. The method of claim 33 wherein said core tube provided in step (a) comprises an innermost core tube layer of a first thermoplastic material which defines said inner core tube surface, and an outermost core tube layer of a second thermoplastic material which defines said outer core tube surface.

51. The method of claim 50 wherein first thermoplastic material is chemically-resistant, and wherein said second polymeric material has a flexural modulus which is lower than the flexural modulus of said first polymeric material.

52. The method of claim 51 wherein said first thermoplastic material comprises a fluoropolymer, and wherein said second thermoplastic material is selected, independently, from the group consisting of polyamides, polyolefins, polyvinyl chlorides, polyurethanes, polyesters, polyacetals, ethylene vinyl alcohol, polyoxymethylene, silicones, thermoplastic rubbers, fluoropolymers, polyolefins, and copolymers and blends thereof.

53. The method of claim 33 wherein said first fiber and said second fiber are selected, independently, from the group consisting of nylon fibers, polyester fibers, aramid fibers, polyvinyl alcohol fibers, polyvinyl acetate fibers, polyolefin fibers, polyphenylene bezobisoxazole fibers, metal wires, and blends thereof.

54. The method of claim 53 wherein said first fiber and said second fiber are the same.

55. The method of claim 33 further comprising the additional step:

(e) surrounding said second fiber reinforcement layer with a cover.

56. The method of claim 55 wherein said cover of step (e) is formed of one or more layers of a polymeric material selected, independently, from the group consisting of polyurethanes, polyamides, polyolefins, silicones, polyesters, fluoropolymers, thermoplastic elastomers, polyvinyl chlorides, polyurethanes, natural and synthetic rubbers, and copolymers and blends thereof.

57. The method of claim 55 wherein said cover of step (e) comprises an innermost cover layer of a first thermoplastic material which defines a circumferential interior cover surface, and an outermost cover layer of a second thermoplastic material which defines a circumferential exterior cover surface.

58. The method of claim 57 wherein said first thermoplastic material has a flexural modulus which is lower than the flexural modulus of said second thermoplastic material, and wherein said outermost layer is formed of a second polymeric material which has a hardness of at least about 60 Shore A durometer.

59. The method of claim 58 wherein said first thermoplastic material is selected from the group consisting of polyamides, polyolefins, polyvinyl chlorides, silicones, fluoropolymers, polyurethanes, natural and synthetic rubbers, and copolymers and blends thereof, and wherein said second thermoplastic material is selected, independently, from the group consisting of polyamides, polyurethanes, polyesters, polyolefins, fluoropolymers, and copolymers and blends thereof.

60. The method of claim 55 wherein said cover of step (e) has a circumferential interior cover surface and an opposing circumferential exterior cover surface, said interior cover surface being bonded to said second reinforcement layer.

61. The method of claim 33 wherein:

said first reinforcement layer is provided in step (b) as formed from one or more ends of a first yarn comprised of filaments of said first fiber, said first yarn having an outer course of filaments of said first fiber which defines a circumferential first outer reinforcement surface disposed adjacent said second reinforcement layer, substantially only said outer course of filaments of said first reinforcement layer being wetted by said bonding agent in step (d); and

said second reinforcement layer is provided in step (c) as formed from one or more ends of a second yarn comprised of filaments of said second fiber; said second yarn as braided or wound over said first reinforcement layer having an inner course of filaments of said second fiber which defines a circumferential second inner reinforcement surface disposed adjacent said first reinforcement layer, substantially only said inner course of filaments of said second reinforcement layer being wetted by said bonding agent in step (d).

62. The method of claim 33 wherein:

said first reinforcement layer is provided in step (b) as formed from one or more ends of a first yarn comprised of a blend or cord of filaments of said first fiber and a third fiber different from said first fiber; and

said second reinforcement layer is provided in step (c) as formed from one or more ends of a second yarn comprised of a blend or cord of filaments of said second fiber and a fourth fiber different from said second fiber,

said first and said second fiber being selected to be wetted in step (d) by said bonding agent, and said third and fourth fibers being selected to be substantially not wetted in step (d) by said bonding agent.

63. The method of claim 33 wherein:

said first reinforcement layer is provided in step (b) as formed from one or more ends of a first yarn comprised of filaments of said first fiber, and one or more ends of a third yarn

different from said first yarn comprised of filaments of a third fiber different from said first fiber; and

said second reinforcement layer is provided in step (c) as formed from one or more ends of a second yarn comprised of filaments of said second fiber, and one or more ends of a fourth yarn different from said second yarn comprised of filaments of a fourth fiber different from said second fiber,

said first and said second fiber being selected to be wetted in step (d) by said bonding agent, and said third and fourth fibers being selected to be substantially not wetted in step (d) by said bonding agent.

64. The method of claim 62 wherein:
said first fiber and said second fiber are the same; and
said third and said fourth fiber are the same.

65. The method of claim 63 wherein:
said first fiber and said second fiber are the same; and
said third and said fourth fiber are the same.